Geologic Resource Evaluation Scoping Summary
Mammoth Cave National Park

Geologic Resources Division
National Park Service
US Department of the Interior

The Geologic Resource Evaluation (GRE) Program provides each of 270 identified natural area National Park Service units with a geologic scoping meeting, a digital geologic map, and a geologic resource evaluation report. Geologic scoping meetings generate an evaluation of the adequacy of existing geologic maps for resource management, provide an opportunity for discussion of park-specific geologic management issues and, if possible, include a site visit with local experts. The purpose of these meetings is to identify geologic mapping coverage and needs, distinctive geologic processes and features, resource management issues, and potential monitoring and research needs. Outcomes of this scoping process are a scoping summary (this report), a digital geologic map, and a geologic resource evaluation report.

The National Park Service held a GRE scoping meeting for Mammoth Cave National Park on June 15-16, 2006 at Mammoth Cave National Park in Kentucky. Tim Connors (NPS-GRD) and Jim Chappell (Colorado State University) facilitated the discussion of map coverage and Bruce Heise (NPS-GRD) led the discussion regarding geologic processes and features at the park. Art Palmer (Cave Research Foundation – State University of New York) presented an overview of the geology in the park area (see below geologic setting), and Ron Kerbo (NPS – GRD) presented an overview of cave and karst features and processes. Participants at the meeting included NPS staff from the park, Geologic Resources Division, Kentucky Geological Survey, Cumberland Piedmont Network, as well as area experts from the Cave Research Foundation, State University of New York, and Kentucky University, and cooperators from Colorado State University (see table 2). This scoping summary highlights the GRE scoping meeting for Mammoth Cave National Park including the geologic setting, the plan for providing a digital geologic map, a prioritized list of geologic resource management issues, a description of significant geologic features and processes, lists of recommendations and action items, and a record of meeting participants.

Park and Geologic Setting

Mammoth Cave National Park was established on July 1, 1941 to preserve the longest cave system in the world (more than 344 km long and increasing with new exploration). The 52,830.19-acre (Federal: 52,003.24 Nonfederal: 826.95) park also protects portions of the scenic Green River and Nolin River valleys as well as the rolling forested hills of west-central Kentucky within the Interior Low Plateau on the southeastern edge of the Illinois Sedimentary Basin (Meiman, 2006). This park was designated a world heritage site on October 27, 1981 and was also designated an international biosphere reserve in 1990. The biosphere covers an area much larger than the park itself.

The landscape of the Mammoth Cave area is characterized by rolling hills, plateau areas dissected by steep-sided, winding rivers, and sinkholes. The rocks underlying the area are Mississippian to Pennsylvanian age sedimentary deposits and are almost horizontal. Tilting of the layers towards the northwest ranges between just a few degrees from absolute horizontal. Many of the rocks in the area are rich in limestone and susceptible to dissolution from percolating groundwater. Three such units, the St. Louis, Ste. Genevieve, and Girkin Formations support extensive cave development. In the

Mammoth Cave area, the limestone rocks are covered by a cap of relatively insoluble cap rocks containing sandstone and shale layers (Big Clifty, Haney, Hardinsburg, Leitchfield, and Caseyville Formations). Where these rocks are absent, such as on the nearby Pennyroyal Plateau, the limestone is readily dissolving away, lowering the land surface dramatically.

The development of Mammoth Cave is intimately connected with the geologic setting of the area. Mammoth Cave National Park lies at the edge of the Chester Upland, characterized by insoluble rock capped ridges such as Flint, Joppa, Ollie, Mammoth Cave, and Collie Ridges are separated by deeply eroded stream and river valleys with limestone floors such as Houchins, Doyel, Woolsey, Green River, and Nolin River Valleys. The Green River is the major regional drain for all surface and groundwater. This river controls cave development rates and patterns (Palmer 1981).

Mammoth Cave is characterized by several different levels of passageways stacked atop one another. The patterns are complex and passages are superimposed upon one another in map view. Development in this way is controlled in part by temporary stalling or slowing of downcutting of the Green River through time. Changes in river erosion rates are intimately connected with climatic shifts. Stable climates slowed river erosion and caused extensive passageway development, whereas climatic shifts (such as those during ice age events) causes the river to cut downward and move the active cave development to a lower stratigraphic level.

Geologic Mapping for Mammoth Cave National Park

During the scoping meeting Tim Connors (NPS-GRD) and Jim Chappell (Colorado State University) showed some of the main features of the GRE Programs digital geologic maps, which reproduce all aspects of paper maps, including notes, the legend, and cross sections, with the added benefit of GIS compatibility. The NPS GRE Geology-GIS Geodatabase Data Model incorporates the standards of digital map creation set for the GRE Program. Staff members digitize maps or convert digital data to the GRE digital geologic map model using ESRI ArcMap software. Final digital geologic map products include data in geodatabase, shapefile, and coverage format, layer files, FGDC-compliant metadata, and a Windows HelpFile that captures ancillary map data.

When possible, the GRE program provides large scale (1:24,000) digital geologic map coverage for each park's area of interest, usually composed of the 7.5-minute quadrangles that contain park lands (figure 1). Maps of this scale (and larger) are useful to resource management because they capture most geologic features of interest and are positionally accurate within 40 feet. The process of selecting maps for management use begins with the identification of existing geologic maps and mapping needs in vicinity of the park. Scoping session participants then select appropriate source maps for the digital geologic data to be derived by GRE staff. Table 1 lists the source maps chosen for Mammoth Cave National Park (MACA).

During the scoping session, MACA staff spoke of the biosphere boundary around MACA and said they would like complete geologic information up to that boundary. To this end, GRE staff will convert all of the supplied KYGS digital geologic data up to the boundary of the biosphere to include the full extent of the involved quadrangles, and additionally will convert the entire Magnolia 7.5' quadrangle to create a seamless corridor between ABLI and the MACA biosphere reserve.

Lillian Scoggins (NPS-MACA) supplied GRE staff with the digital file showing this boundary and it is shown below.

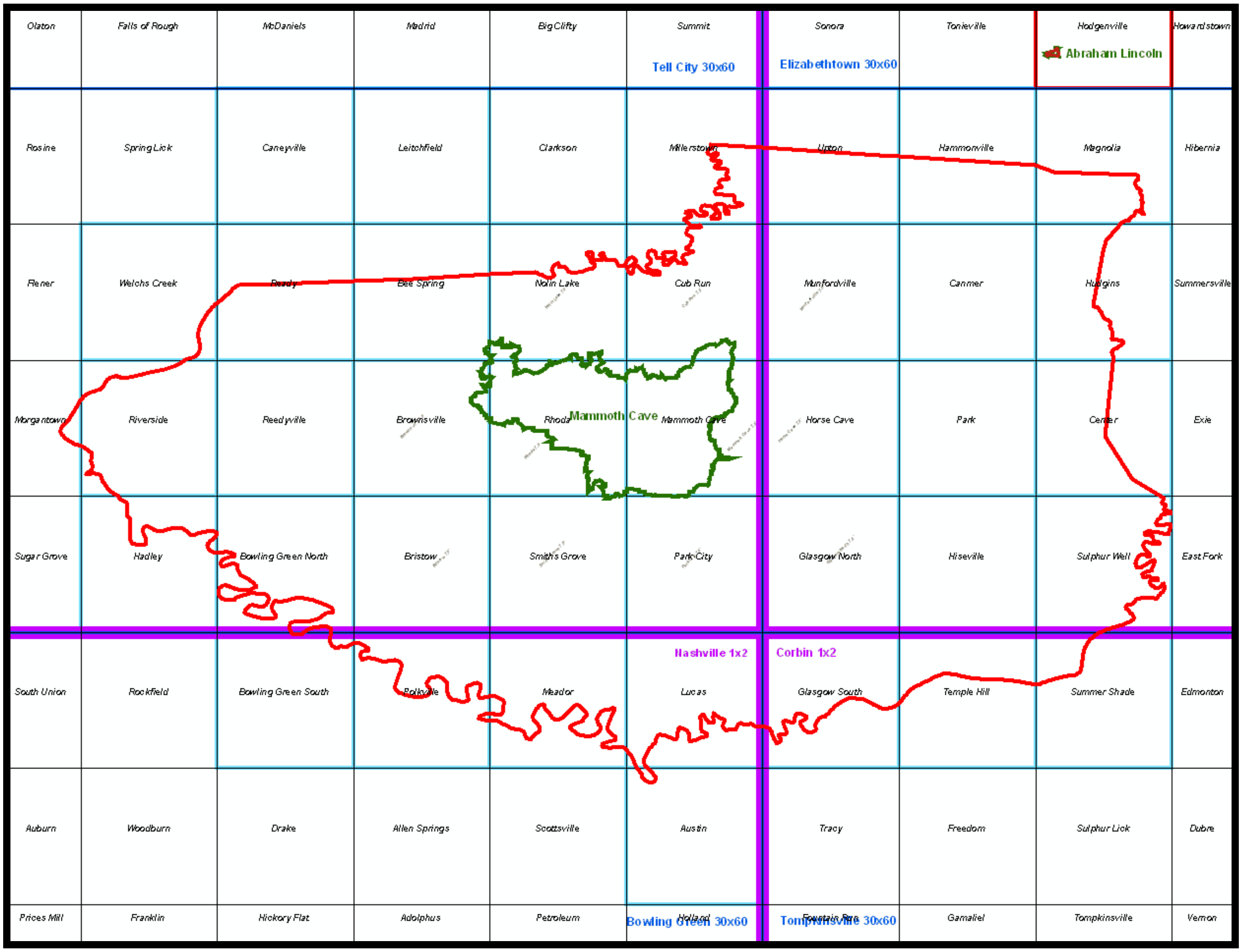

Figure 1. Extent of Biosphere boundary (red) overlain on MACA park boundary (green) and 7.5' quadrangles

Please note the dramatic increase in the number of 7.5' quadrangles comprised in the biosphere boundary as follows (**bolding shows "original" extent of quadrangles touching MACA boundary**): Magnolia, Hammonville, Upton, Millerstown, Hudgins, Canmer, Munfordville, **Cub Run**, **Nolin Lake**, **Bee Spring**, Ready, Welchs Creek, Center, Park, Horse Cave, **Mammoth Cave**, **Rhoda**, **Brownsville**, Reedyville, Riverside, Morgantown, Sulphur Well, Hiseville, Glasgow North, **Park City, Smiths Grove**, Bristow, Bowling Green North, Hadley, Summer Shade, Temple Hill, Glasgow South, Lucas, Meador, Polkville, Bowling Green South, and Austin.

Each 7.5' quadrangle in the state of Kentucky has a corresponding geologic map in paper format and also likely has already been translated into a digital format by the Kentucky Geological Survey as well, so no new mapping is required to complete the biosphere area.

All of the 7.5’ quadrangles contained on both the Beaver Dam and Campbellsville 30x60 sheets have “preliminary” digital files produced by the KYGS and have been obtained by GRE staff. Additionally, the remaining 7.5’ quadrangles intersecting the biosphere boundary contained on the Bowling Green 30x60 and Tompkinsville 30x60 have been released by the KYGS as individual digital geologic maps. A few statewide themes for sinkholes and oil-gas will also be included.

The following table lists the source maps covering the MACA area of interest.

GRE Mapping Plan for Mammoth Cave National Park

[1]GMAP numbers are unique identification codes used in the GRE database.

100k	GMAP	REFERENCE	scale	GRE Acquired
Campbellsville 30 x 60	74444	Kentucky Geological Survey, 2006, Spatial Database of the **Campbellsville** 30 x 60 minute quadrangle, Kentucky, Kentucky Geological Survey, , 1:100000 scale; *Please note this is the digital version of 32 individual 7.5' geologic maps that are presented as a single compilation. GRE staff will extract and convert specific 7.5' quadrangles that comprise the MACA biosphere area of interest for the following: Magnolia; Hammonville; Upton; Hudgins; Canmer; Munfordville; Center; Park; Horse Cave; Sulphur Well; Hiseville; Glasgow North.* *Source information for these specific maps is presented below.*	100000	digital
	2756	Moore, F.B., 1975, Geologic map of the **Magnolia** Quadrangle, central Kentucky, U.S. Geological Survey, GQ-1280, 1:24000 scale	24000	paper
	74453	unknown, 2006, Unpublished Spatial Database of the **Magnolia** quadrangle, central Kentucky, Kentucky Geological Survey, Digitally Vectorized Geologic Quadrangle Map DVGQ-1280, 1:24000 scale	24000	digital
	74454	unknown, 2006, Unpublished Spatial Database of the **Hammonville** quadrangle, Larue and Hart Counties, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geologic Quadrangle Map DVGQ-1051, 1:24000 scale	24000	digital
	2757	Moore, F.B., 1972, Geologic map of the **Hammonville** quadrangle, Larue and Hart Counties, Kentucky, U.S. Geological Survey, GQ-1051, 1:24000 scale	24000	paper
	74455	unknown, 2006, Unpublished Spatial Database Geologic map of the **Upton** quadrangle, central Kentucky, Kentucky Geological Survey, Digitally Vectorized Geologic Quadrangle Map GQ-1000, 1:24000 scale	24000	digital
	2758	Moore, F.B., 1972, Geologic map of the **Upton** quadrangle, central Kentucky, U.S. Geological Survey, GQ-1000, 1:24000 scale	24000	paper
	7341	Miller, R.C. and Moore, S.L., 1969, Geologic map of the **Hudgins** quadrangle, Green and Hart Counties, Kentucky, U.S. Geological Survey, Geologic Quadrangle Map GQ-834, 1:24000 scale	24000	
	74457	unknown, 2006, Unpublished Spatial Database Geologic map of the **Hudgins** quadrangle, Green and Hart Counties, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geologic Quadrangle Map DVGQ-834, 1:24000 scale	24000	digital
	74458	unknown, 2006, Unpublished Spatial Database of the Geologic map of the **Canmer** quadrangle, Hart County, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geologic Quadrangle Map DVGQ-816, 1:24000 scale	24000	digital
	2754	Miller, R.C., 1969, Geologic map of the **Canmer** quadrangle, Hart County, Kentucky, , Geologic Quadrangle Map GQ-816, 1:24000 scale	24000	paper
	1161	Moore, Samuel L., 1973, Geologic map of the **Munfordville** quadrangle, Hart County, Kentucky, U.S. Geological Survey, GQ-1055, 1:24000 scale	24000	paper
	74459	unknown, 2006, Unpublished Spatial Database Geologic map of the **Munfordville** quadrangle, Hart County, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geologic Quadrangle Map DVGQ-1055, 1:24000 scale	24000	digital
	74462	unknown, 2006, Unpublished Spatial Database Geologic map of the **Center** quadrangle, south-central Kentucky, Kentucky Geological Survey, Digitally Vectorized Geologic Quadrangle Map DVGQ-693, 1:24000 scale	24000	digital
	2755	Miller, R.C. and Moore, S.L., 1967, Geologic map of the **Center** quadrangle, south-central Kentucky, U.S. Geological Survey, GQ-693, 1:24000 scale	24000	paper

100k	GMAP	REFERENCE	scale	GRE Acquired
	74463	unknown, 2006, Unpublished Spatial Database Geologic map of the **Park** quadrangle, south-central Kentucky, Kentucky Geological Survey, Digitally Vectorized Geologic Quadrangle Map DVGQ-634, 1:24000 scale	24000	digital
	2762	Moore, S.L. and Haynes, D.D., 1967, Geologic map of the **Park** quadrangle, south-central Kentucky, U.S. Geological Survey, GQ-634, 1:24000 scale	24000	no
	74464	unknown, 2006, Unpublished Spatial Database Geologic map of the **Horse Cave** quadrangle, Barren and Hart Counties, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geologic Quadrangle Map DVGQ-558, 1:24000 scale	24000	digital
	1160	Haynes, Donald D., 1966, Geologic map of the **Horse Cave** quadrangle, Barren and Hart Counties, Kentucky, U.S. Geological Survey, GQ-558, 1:24000 scale	24000	paper
	2742	Cattermole, J.M., 1966, Geologic map of the **Sulphur Well** quadrangle, Metcalfe and Green Counties, Kentucky, U.S. Geological Survey, GQ-555, 1:24000 scale	24000	paper
	74468	unknown, 2006, Unpublished Spatial Database Geologic map of the **Sulphur Well** quadrangle, Metcalfe and Green Counties, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geologic Quadrangle Map DVGQ-555, 1:24000 scale	24000	digital
	2750	Haynes, D.D., 1965, Geology of the **Hiseville** quadrangle, Kentucky, U.S. Geological Survey, GQ-401, 1:24000 scale	24000	paper
	74469	unknown, 2006, Unpublished Spatial Database Geology of the **Hiseville** quadrangle, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geologic Quadrangle Map DVGQ-401, 1:24000 scale	24000	digital
	74470	unknown, 2006, Unpublished Spatial Database of the Geology of the **Glasgow North** quadrangle, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geologic Quadrangle Map DVGQ-339, 1:24000 scale	24000	digital
	1159	Haynes, Donald D., 1964, Geology of the **Glasgow North** quadrangle, Kentucky, U.S. Geological Survey, GQ-339, 1:24000 scale	24000	paper

100k	GMAP	REFERENCE	scale	GRE Acquired
Beaver Dam 30 x 60	74443	Kentucky Geological Survey , 2002, Spatial Database of the **Beaver Dam** 30 x 60 minute quadrangle, Kentucky, Kentucky Geological Survey, , 1:100000 scale; *Please note this is the digital version of 32 individual 7.5' geologic maps that are presented as a single compilation. GRE staff will extract and convert specific 7.5' quadrangles that comprise the MACA biosphere area of interest for the following: Millerstown, Cub Run, Nolin Reservoir, Bee Spring, Ready, Welchs Creek, Mammoth Cave, Rhoda, Brownsville, Reedyville, Riverside, Morgantown, Park City, Smiths Grove, Bristow, Bowling Green North, Hadley.* *Source information for these specific maps is presented below.*	100000	digital
	2759	Moore, F.B., 1965, Geology of the **Millerstown** quadrangle, Kentucky, U.S. Geological Survey, GQ-417, 1:24000 scale	24000	paper
	74456	unknown, 2006, Unpublished Spatial Database Geology of the **Millerstown** quadrangle, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geologic Quadrangle Map DVGQ-417, 1:24000 scale	24000	digital
	1158	Sandberg, C.A. and Bowles, C.G., 1965, Geology of the **Cub Run** quadrangle, Kentucky, , Geologic Quadrangle Map GQ-386, 1:24000 scale	24000	paper & digital
	74435	Toth, K.S, 2002, Spatial database of the **Cub Run** quadrangle, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geological Quadrangle DVGQ-386, 1:24000 scale	24000	digital
	74436	Toth, K.S, 2002, Spatial database of the **Nolin Reservoir** quadrangle, western Kentucky, Kentucky Geological Survey, Digitally Vectorized Geological Quadrangle DVGQ-895, 1:24000 scale	24000	digital
	1162	Gildersleeve, Benjamin, 1971, Geologic map of the **Nolin Reservoir** quadrangle, western Kentucky, U.S. Geological Survey, GQ-895, 1:24000 scale	24000	paper & digital
	1156	Gildersleeve, Benjamin, 1968, Geologic map of the **Bee Spring** quadrangle, Edmonson and Grayson Counties, Kentucky, U.S. Geological Survey, GQ-757, 1:24000 scale	24000	paper & digital
	74437	Mullins, J.E., 2002, Spatial database of the **Bee Spring** quadrangle, Edmonson and Grayson Counties, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geological Quadrangle DVGQ-757, 1:24000 scale	24000	digital
	2745	Gildersleeve, Benjamin, 1975, Geologic map of the **Ready** quadrangle, western Kentucky, U.S. Geological Survey, GQ-1263, 1:24000 scale	24000	paper

100k	GMAP	REFERENCE	scale	GRE Acquired
	74460	unknown, 2006, Unpublished Spatial Database Geologic map of the **Ready** quadrangle, western Kentucky, Kentucky Geological Survey, Digitally Vectorized Geologic Quadrangle Map DVGQ-1263, 1:24000 scale	24000	digital
	74461	unknown, 2006, Unpublished Spatial Database Geologic map of the **Welchs Creek** quadrangle, Butler and Grayson Counties, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geologic Quadrangle Map DVGQ-1339, 1:24000 scale	24000	digital
	2744	Gildersleeve, Benjamin, 1976, Geologic map of the **Welchs Creek** quadrangle, Butler and Grayson Counties, Kentucky, U.S. Geological Survey, GQ-1339, 1:24000 scale	24000	paper
	1546	Haynes, D.D., 1964, Geology of the **Mammoth Cave** quadrangle, Kentucky, U.S. Geological Survey, Geologic Quadrangle Map GQ-351, 1:24000 scale	24000	paper
	74438	Davidson, S.T., 2002, Spatial database of the **Mammoth Cave** quadrangle, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geological Quadrangle DVGQ-351, 1:24000 scale	24000	digital
	74439	Toth, K.S, 2002, Spatial database of the **Rhoda** quadrangle, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geological Quadrangle DVGQ-219, 1:24000 scale	24000	digital
	1164	Klemic, Harry, 1963, Geology of the **Rhoda** quadrangle, Kentucky, U.S. Geological Survey, GQ-219, 1:24000 scale	24000	paper & digital
	74440	Mullins, J.E., 2002, Spatial database of the **Brownsville** quadrangle, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geological Quadrangle DVGQ-411, 1:24000 scale	24000	digital
	1157	Gildersleeve, Benjamin, 1965, Geology of the **Brownsville** quadrangle, Kentucky, U.S. Geological Survey, GQ-411, 1:24000 scale	24000	paper & digital
	74465	unknown, 2006, Unpublished Spatial Database Geologic map of the **Reedyville** quadrangle, western Kentucky, Kentucky Geological Survey, Digitally Vectorized Geologic Quadrangle Map DVGQ-520, 1:24000 scale	24000	digital
	2769	Shawe, F.R., 1966, Geologic map of the **Reedyville** quadrangle, western Kentucky, U.S. Geological Survey, GQ-520, 1:24000 scale	24000	paper
	74466	unknown, 2006, Unpublished Spatial Database Geologic map of the **Riverside** quadrangle, Butler and Warren Counties, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geologic Quadrangle Map DVGQ-736, 1:24000 scale	24000	digital
	2768	Shawe, F.R., 1968, Geologic map of the **Riverside** quadrangle, Butler and Warren Counties, Kentucky, U.S. Geological Survey, GQ-736, 1:24000 scale	24000	paper
	74467	unknown, 2006, Unpublished Spatial Database Geologic map of the **Morgantown** quadrangle, Butler and Warren Counties, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geologic Quadrangle Map DVGQ-1040, 1:24000 scale	24000	digital
	15793	Gildersleeve, Benjamin, 1972, Geologic map of the **Morgantown** quadrangle, Butler and Warren Counties, Kentucky, , Geologic Quadrangle Map GQ-1040, 1:24000 scale	24000	
	74441	Thompson, M.F, 2002, Spatial database of the **Park City** quadrangle, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geological Quadrangle DVGQ-183, 1:24000 scale	24000	digital
	1163	Haynes, Donald D., 1962, Geology of the **Park City** quadrangle, Kentucky, U.S. Geological Survey, GQ-183, 1:24000 scale	24000	paper & digital
	74442	Thompson, M.F, 2002, Spatial database of the **Smiths Grove** quadrangle, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geological Quadrangle DVGQ-357, 1:24000 scale	24000	digital
	1165	Richards, Paul W., 1964, Geology of the **Smiths Grove** quadrangle, Kentucky, U.S. Geological Survey, GQ-357, 1:24000 scale	24000	paper & digital
	2746	Gildersleeve, Benjamin, 1963, Geology of the **Bristow** quadrangle, Kentucky, U.S. Geological Survey, GQ-216, 1:24000 scale	24000	paper
	74471	unknown, 2006, Unpublished Spatial Database of the Geology of the **Bristow** quadrangle, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geologic Quadrangle Map GQ-216, 1:24000 scale	24000	digital
	2770	Shawe, F.R., 1963, Geology of the **Bowling Green North** quadrangle, Kentucky, U.S. Geological Survey, GQ-234, 1:24000 scale	24000	paper & digital
	74472	unknown, 2006, Unpublished Spatial Database of the Geology of the **Bowling Green North** quadrangle, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geologic Quadrangle Map DVGQ-234, 1:24000 scale	24000	digital
	2766	Rainey, H.C., 1963, Geology of the **Hadley** quadrangle, Kentucky, U.S. Geological Survey, GQ-237, 1:24000 scale	24000	paper
	74473	unknown, 2006, Unpublished Spatial Database of the Geology of the **Hadley** quadrangle, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geologic Quadrangle Map DVGQ-237, 1:24000 scale	24000	digital

100k	GMAP	REFERENCE	scale	GRE Acquired
The following represent individually published paper and digital 7.5' quadrangle maps that each will be converted by GRE staff *Source information for these specific maps is presented below.*				
Tompkinsville 30 x 60	2749	Hail, W.J., 1964, Geology of the **Summer Shade** quadrangle, Kentucky, U.S. Geological Survey, GQ-308, 1:24000 scale	24000	paper
	74445	, 2006, Digital Geology of the **Summer Shade** quadrangle, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geologic Quadrangle Map --, 1:24000 scale	24000	digital
	2764	Moore, S.L. and Miller, R.C., 1965, Geology of the **Temple Hill** quadrangle, Barren County, Kentucky, U.S. Geological Survey, GQ-402, 1:24000 scale	24000	paper
	74446	, 2006, Digital Geology of the **Temple Hill** quadrangle, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geologic Quadrangle Map --, 1:24000 scale	24000	digital
	2763	Moore, S.L. and Miller, R.C., 1965, Geology of the **Glasgow South** quadrangle, Barren County, Kentucky, U.S. Geological Survey, GQ-416, 1:24000 scale	24000	paper
	74447	, 2006, Digital Geology of the **Glasgow South** quadrangle, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geologic Quadrangle Map --, 1:24000 scale	24000	digital
Bowling Green 30 x 30	2752	Haynes, D.D., 1963, Geology of the **Lucas** quadrangle, Kentucky, U.S. Geological Survey, GQ-251, 1:24000 scale	24000	paper
	69794	Mullins, J.E., 2003, Spatial database of the **Lucas** quadrangle, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geological Quadrangle DVGQ-12_251, 1:24000 scale	24000	digital
	2765	Nelson, W.H., 1963, Geology of the **Meador** quadrangle, Kentucky, U.S. Geological Survey, GQ-288, 1:24000 scale	24000	paper
	69800	Thompson, M.F., 2003, Spatial database of the **Meador** quadrangle, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geological Quadrangle DVGQ-12_288, 1:24000 scale	24000	digital
	2747	Gildersleeve, Benjamin, 1962, Geology of the **Polkville** quadrangle, Kentucky, U.S. Geological Survey, GQ-194, 1:24000 scale	24000	paper
	69792	Thompson, M.F., 2003, Spatial database of the **Polkville** quadrangle, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geological Quadrangle DVGQ-12_194, 1:24000 scale	24000	digital
	2771	Shawe, F.R., 1963, Geology of the **Bowling Green South** quadrangle, Kentucky, U.S. Geological Survey, GQ-235, 1:24000 scale	24000	paper
	69793	Thompson, M.F., 2003, Spatial database of the **Bowling Green South** quadrangle, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geological Quadrangle DVGQ-12_235, 1:24000 scale	24000	digital
	2761	Moore, S.L., 1961, Geology of the **Austin** quadrangle, Kentucky, U.S. Geological Survey, GQ-173, 1:24000 scale	24000	paper
	69789	Johnson, T.L.;Thompson, M.F., 2003, Spatial database of the **Austin** quadrangle, Kentucky, Kentucky Geological Survey, Digitally Vectorized Geological Quadrangle DVGQ-12_173, 1:24000 scale	24000	digital
The following represent individual digital datasets from the state of Kentucky featuring statewide themes that will be converted by GRE staff *Source information for these specific maps is presented below.*				
N / A	53392	Carey, D.I.;Nuttall, B.C., 1995, Distribution of oil and gas wells in Kentucky, Kentucky Geological Survey, Map and Chart Series MCS-11_009, 1:1000000 scale	1000000	digital
	74479	Paylor, Randall L., Florea, Lee, Caudill, Michael, and Currens, James C., 2003, A GIS Sinkhole Coverage for the Karst areas of Kentucky, 137, unpublished, 1:24000 scale	24000	digital

The following are items of interest pertaining to the conversion of the KYGS digital data:

- Every paper map containing a cross section will need to be captured; GRE staff can use the KYGS digital SIDs to derive them

- Some mine features, such as adits, were not consistently captured from the original source maps and will have to be digitized separately from scanned images of the paper maps. Likewise, it may also be necessary to capture quarries, gravel pits and other mine features. Also, abandoned coal strip mines were not captured in the Beaver Dam 30x60 from the source image for the Brownsville quad. If GRE desires such features we will need to capture them; KYGS will not be adding these additional features to their data so these will need to be digitized by GRE staff

- Adits that were captured will need to be rotated to match the source map.

- In several observed instances (ie. Hodgenville 7.5' for ABLI) unit naming and 'lumping' has been carried out differently between the source paper map and the digital data; these "anomalies" will need to be identified and reconciled or explained. It will be up to GRE staff to find these instances and best address / resolve them. Matt Crawford can answer questions if needed regarding unit designations.

- Not all of the KYGS data is currently published or complete, leading to the potential for errors in the data. For example, incorrect strike (rotation) of attitude points was found (Hodgenville quad, corrected by Matt Crawford), as well as missing coal outcrop location points. Only processing and metadata remain for "incomplete" datasets. There is no time frame for when these might be completed. Legitimate errors in KYGS data should be reported to Matt Crawford. Again, he might resolve depending on the scope of what needs to be done.

- Additional KYGS data (such as oil and gas wells [GMAP=53392], sinkholes, coal seams, karst) comes separately from the supplied larger scale geologic data (24k and 100k) and is statewide. In some cases, the oil and gas wells do not match the source images downloaded from the KYGS website. Do we go with the location of the digital data? This needs more discussion to determine if additional KYGS data gets included with the NPS product. Will need to research and consult with KYGS to determine cause of offset. Oil and gas did come up and there was general interest in well locations inside and outside of the park boundary with regards to revealing structure info. Matt Crawford said he would look into. There was also interest in well status – active, plugged, etc.

- **Landuse planning maps:** KYGS derivative products of "simplified" geologic maps targeted for the non-geologist. They are thematic in that they are catered to a specific subject, such as landuse. The park is interested in creating something similar from their geologic data; KYGS (Matt Crawford) is willing to create something of the like for MACA.

- **Faults:** There was some discussion about fault data (or the lack thereof) in that it is likely in reality there are more faults that exist than are shown on maps. Art Palmer has some data (mapped from inside the cave system) but we did not discuss in detail what he has or whether he is willing to share his information with GRE staff.

- **Cave data GDB:** Aaron Addison(GIS Coordinator- Washington University of St. Louis) presented his geodatabase model and the work he is doing both as a volunteer and for his thesis. There was some discussion about linking the NPS product with the cave geodatabase; it is suggested to maintain communication on this subject to see what might be developed.

- **Groundwater flow maps:** on CD; Some interest in these. These maps figure more into the 3D component of this park, but could be displayed OK in 2D. ***However, this is non-GRE and***

should be asked to be included for the water inventory.

- **Reservoir mapping:** The park expressed some interest in geologic units beneath water reservoirs. Source map authors may be the best source for this level of interpretation.

Geologic Resource Management Issues

The scoping session for Mammoth Cave National Park provided the opportunity to develop a list of geologic features and processes, which will be further explained in the final GRE report. During the meeting, participants prioritized the most significant issues as follows:
(1) Cave and karst issues,
(2) Fluvial issues, and
(3) Mass wasting.

Other geologic resource management issues discussed included: cave mapping, disturbed lands, paleontological resources, aeolian deposits and airflow.

Cave and Karst Issues

- Geology – Rocks provide the physical framework of cave and karst systems. Detailed modeling of cave and karst geologic settings needs to be refined. To understand the cave system, surface and subsurface geologic mapping can always be expanded upon and improved. Geologic controls such as composition, fracturing and jointing, layering, and orientation are important to relate to karst development. The park has interest in further research into the geohydrologic history of karst development in the area. This knowledge would help with concerns of impacts from outside the park.

  Features within caves such as speleothems and speleogens contain invaluable information regarding cave development. Disruptive sampling and preservation of speleothems at Mammoth Cave are two conflicting actions. The park needs to determine a proper balance of using speleothems for scientific research and preserving existing features within the caves. Past sampling may be tapped as a resource for C-O isotope, and paleoflora studies. All samples taken from Mammoth Cave should be curated at the park. Speleogens such as small pits, primary mineralization, domes, scallops, etc. record conditions during the primary development as a particular cave is beginning to form.

- Hydrology – The hydrologic system of each cave and karst system is unique and dynamic. The system at Mammoth Cave is vast and diverse, covering hundreds of square miles. Data needed to manage this resource includes geochemical composition and monitoring, isotope studies (O_2) of flowing and dripping water, water quality monitoring, and increased natural and introduced flow tracer studies. Understanding how and where groundwater is flowing from the surface, through aquifers and cave conduits, towards the Green River is vital in predicting hydrologic system response to contaminants and other impacts from outside development. To this end, further delineation of aquifers, flow systems, groundwater/surface water interactions, recharge mechanisms and pathways, as well as the effects of changes in recharge rates and pumping would help refine the hydrogeologic system model at Mammoth Cave to help resource management.

- Biology and Ecosystem Health – Inherent in most cave and karst system are specialized, fragile and vulnerable biological ecosystems. These ecosystems are intricately tied to the hydrology and geology of the caves. A biological inventory at the park with future monitoring would be a good start to understanding the nature of these systems. Biological resource studies could include macrobiology, microbiology/biofilm, as well as endangered-threatened-sensitive species surveys. Some invasive algae are present in the lighted cave areas, but so far are not a critical concern to park resource management. The presence of these so-called lampen flora are managed using light stations along tour routes to avoid continuous light exposure. Different color lights are also being tested to determine if a specific color might reduce the effects of invasive microorganisms in the caves. Knowledge of biogeochemical cycling is critical to understand the relationship between ecosystem health and water quality as well as to perform an ecological risk assessment.

The park is particularly interested in modeling cave and karst ecological systems. Organisms play an undefined role in speleogenesis and other karst processes. Studies of the role of organisms on calcite deposition and dissolution are valuable to cave management as well as organism - nitrate studies. More information on the biology of the cave and karst ecosystem will help predict sensitivity of the system to changes or disturbances in the cave environment whether geological, hydrological, or anthropogenic in origin.

- Cave Microclimate – Compared to surface climatic conditions in west-central Kentucky, the cave microclimate is relatively stable and moderate. Inside the cave, annual temperatures range between 55-57 degrees F (13-14 degrees C) and the air is humid. This environment is vital in maintaining the unique cave resources and processes at Mammoth Cave National Park, but natural forces and human activities (overcrowding, excessive lighting, etc) can easily alter this system. Changes in the cave's microclimate may affect the biota, mineralogy, cave formation, airflow dynamics, air quality, dust dispersion, etc., and condensation, corrosion, and redeposition of speleothems. In as much as the microclimate is related to airflow, understanding the cave conditions may help predict rockfall in areas identified as prone to failure and allow condensation problems to be prevented. Airflow mapping is a vital need for resource management at the park.

- Hazards – There are several hazards unique to cave and karst environments including the confined nature of caves, underground flooding, sinkhole collapse, rockfall and instability in caves, gas movement and concentration (radon, carbon dioxide, toxic vapors, etc.), presence of bat guano, etc. Guano is responsible for hystoplasmosis, a fungal infection known as "valley fever". Certain activities such as mining, blasting, quarrying, and drilling as well as simple human use can precipitate geologic hazards in a cave and karst environment. Understanding the environmental effects on human health is vital for park resource managers to protect cave visitors and staff.

Fluvial Issues

The Green River is the baseline for cave development and the drain for all surface and groundwater at Mammoth Cave National Park. Flooding along this river poses threats to infrastructure and inundates low-lying caves with water and sediments. Floodplain deposits and terraces along the park's rivers record their stream channel morphology and level through time.

There is a decrepit, navigational, concrete lock and dam (Lock and Dam No. 6) on the Green River. This structure has not been used since the 1950's and is the responsibility of the Army Corps of Engineers. It is located just downstream from the park and affects the Green and Nolin Rivers as well as cave streams throughout the park. As much as one-half of the Green River’s stretch through the park is affected by this manmade structure. First Creek Lake is related to this lock and dam. There are no financial resources available to remove the structure; however, a seasonal flood may be enough to dislodge it. The park is interested in restoring the river to conditions prior to dam construction.

Surface water is rare in the karst landscape at Mammoth Cave. Most rainwater filters quickly through the underground conduits into the cave system and ultimately drains to the Green River. This makes surface water expressions such as springs, disappearing streams, dolines (karst windows), and sinkhole ponds vital to wildlife habitat at the park.

Because surface water reaches the cave system so quickly, land use practices such as agriculture, grazing, logging, feed lots, as well as ground disturbing activities including road construction, sewer maintenance, pipeline construction, mining, quarrying, drilling, urban development, and utility line installation, and structures such as parking lots and buildings can have dramatic effects in the caves and for water quality at Mammoth Cave National Park. When soils and loose sediments are exposed to erosion, they are quickly carried into the cave system below the surface and are deposited in passageways. Species such as cave shrimp are negatively impacted by this deposition. Runoff from parking lots and other facilities act as point sources to carry pollutants directly into the cave’s water system. Chaumont, the Mammoth Cave Hotel, and Visitor Center parking lot runoff drains into an aqueduct near the historic entrance and is causing erosion of gullies, which undermines steps and causes local block fall. A change in road drainage into a sinkhole can have drastic effects on sinkhole morphology and underlying cave structure.

Because of the far-reaching nature of the cave network and its enormous groundwater source (hydrogeologic) area, oil and gasoline spills associated with traffic on the interstate, railroads, and towns have significant potential for adverse impacts on the caves and water quality at the park. A massive transportation hub (TransPark) has been proposed for development in the area west of Bowling Green, KY. This hub would bring together railroad, highway, airline, and manufacturing centers. Park resource managers are concerned that this development would threaten water quality, viewshed, air quality, and create noise and light pollution for the park.

Mass Wasting

In general, the development of sinkholes in a karst landscape is a mass wasting process. On the park road to the Carmichael entrance, a 90 ft deep pit recently developed. Given the degree of karstic dissolution beneath the surface at the park, sinkhole development is a always possibility. Once a sinkhole is created, additional erosion and blockfall into the sinkhole widens the affected area creating a topographic depression. If erosion is extreme, the edges of the sinkhole are softened into a gentle depression on the landscape (similar to Pennyroyal Plateau sinkholes). Near Mammoth Cave, most sinkhole rims are topped with insoluble layers and holes such as Cedar Sink and those near Turnhole bend are steep-sided.

Given the steep sides of the river and stream valleys in the Chester upland area, as well as abundant seasonal precipitation, rockfall, slope creep, and other slope processes are relatively common. Block falls occur at the bases of cliffs at the park and near the entrance areas to caves. Within the caves, rockfall, roof collapse, and exfoliation of wall material are part of the natural cave development.

These rockfalls are usually incremental and happen over a long period. Some of this happens just following the draining of a particular cave, other times spalling may be triggered by rare extreme temperature changes. However, recently, a large block fell from the roof of the Rotunda near the historic entrance to Mammoth Cave due to a misguided reclamation effort to restore airflow during the winter.

Though Mammoth Cave does not contain any known active faults (only the Cub Run fault is mapped in the park), the park is near the West Kentucky Fault Zone, the Rough Creek earthquake zone, and is only some 200 miles from the New Madrid Fault. Historical earthquakes on the New Madrid fault caused some local rockfall and disrupted salt-petre mining operations in the cave. In 1987 a minor earthquake loosened rock on Audubon Avenue. Seismic shaking could possibly trigger mass wasting both inside and outside the park's caves.

Cave Mapping

There are 63 "quadrangles" of variable size that cover various areas of the cave. As cave exploration and description continues this information is constantly being added to and/or changed. Much of this information is present as raster data in Adobe Illustrator, AutoCad, mylars, Compass, etc. formats. Cave data is not adequately supported by GIS architecture. In addition to the ever-expanding Mammoth-Flint Ridge Cave network, there are numerous (more than 300) smaller caves throughout the park that must be identified and protected from visitor use.

Questions regarding cave mapping include (1) who is responsible for maintaining the data? (2) are there significant cave areas beneath existing park infrastructure? (3) when new data is added, what system is in place to ensure integrity between data sets? (4) how can cave raster data be vectorized? (5) how can different resolutions, flavors (based on different mappers, researchers, projects, etc) scales, be captured in one Geodatabase? (6) can having geologic underground mapping stations tied to cave maps facilitate connections with the NPS-GRE digital geologic map? (7) can geology and cave layers being superimposed spatially to determine relationships?

Disturbed Lands

Disturbed areas at Mammoth Cave include access roads, logged areas, and overgrazed areas. Many roads have been removed but not reclaimed and are susceptible to heavy erosion. In addition to these, there are numerous cisterns and old wells from homesites that need to be capped or covered. Many of these were dug by hand prior to the establishment of the park and are approximately 5 feet in diameter and 60 feet deep. The park has a funded project to make these areas safe while preserving any interesting architecture. Job Corps water tanks are being demolished.

The geologic resources of the Mammoth Cave area have attracted humans for hundreds of years. Native Americans first extracted mineral resources including crystals of selenite, epsomite, mirabolite (sodium sulfate), and gypsum from the caves. Cave sediments included mineral salts useful in making gunpowder. In the early 1800's this wealth was exploited in several salt-peter works operations in the cave. Speleothems were removed for commercial sales prior to the NPS protection. There are several old rock quarries (aggregate or limestone?) in the park area.

Mineral exploration and development continue today outside park boundaries. There are nearby asphalt mines that have been dormant, but may be reactivated given the present economic environment. These mines may impact the Nolin River. Thin coal seams northwest of the park (but inside the International Biosphere) of the Tar Springs Sandstone and the Chester Formation support small-scale extraction operations.

Oil and gas exploration occurs along a roughly northeast-southwest trend in the cave area. Production sparked an oil boom in the 1920’s in Barron County. Arthur Oil Field (predates park’s establishment) in Edmonson County is just outside the southwest corner of the park. Most wells are shallow with 10 foot pump jacks. The producing unit is below the St. Louis Formation (Fort Payne Formation?). Groundwater dye tracers indicate groundwater flows from this area into the cave system. Past spills have altered the water quality at the park. There is the possibility that the oil field is extracting oil and gas from beneath the park. There is some question as to whether all former wells within park boundaries have been plugged.

Paleontological Resources

The Mississippian and Pennsylvanian age rocks at Mammoth Cave contain significant fossil resources. Bedrock fossils are exposed at the surface and on the walls of the caves. Exposures in caves include remarkable shark remains (cartilage), numerous invertebrate fossils, corals, crinoids, etc. The first 2-3 miles of the cave have preliminary fossil inventory information. Given the incredible length of the cave system, this inventory should be expanded.

More recent fossil remains are present in cave fill deposits including Tertiary-Quaternary vertebrate remains, pollen, invertebrate remains (washed in from river or indigenous to cave environment), eastern woodrat nests, Early Pleistocene large mammal and bat remains, and modern packrat nests. Floodplain deposits may also contain significant fossil remains.

The park possesses archaeological resources in addition to the fossil resources described above. Humans have been using the caves in the park area since at least 11 Ky. Signatures of their presence include petroglyphs and rock art. Also, 2,200 to 2,400 year old mummified remains were found in the cave as well as rock shelters, torch material, and mineral extraction tools and baskets. Historic remains include signatures and graffiti.

Aeolian deposits and Airflow

Aeolian deposits in the Mammoth Cave area include windblown loess deposits. These are incorporated in soils on local upland areas. Windblown deposits are also found in the cave itself wuch as in Turner Avenue (part of the Flint Ridge Cave) where aeolian deposits are probably linked to a sudden gust of high wind. Aeolian deposits are rare in Mammoth Cave. Wind orientation (aligned with a cave opening) and readily available loose sands and muds are two necessary components for such deposits.

Airflow is incredibly important to many cave processes. Variations in airflow are related to specific speleothems including rims and popcorn. Understanding the chimney effect in the cave, driven by barometric pressure and/or temperature, is vital for cave resource management and visitor comfort.

Features and Processes

Mammoth Cave is the longest cave in the world. It is estimated that in addition to the known 550 or so miles of cave in the biosphere area, this number may possibly reach 800 to 1000 miles upon further exploration and mapping. It displays an incredibly complicated passage network. Equally impressive as the known volume of passageways is the volumn of what is NOT there, i.e. what has been removed by dissolution, represented by vast voids in the rock. Brilliant speleothems including gypsum flowers decorate reaches of the cave. Based on its sheer size alone, this is the prominent feature of the park. It contains evidence of present and past flow regimes. The larger passages are textbook examples of karst tubular passages. Canyons, passages, and domes record conditions of the present and past flow systems of the cave. Specific stratigraphic layers can be traced through the cave passages for miles. This correlated stratigraphy is important for geologic mapping in the caves and identifying particular cave levels.

Karst processes of dissolution and cave development are ongoing and provide unique interpretation opportunities. This system supports ongoing cave excavation with abundant source water, underground conduits, outfall, and relatively pure limestone available for dissolution. Mammoth Cave also provides information for understanding the surrounding area's drainage history since the Miocene. This has interesting connections to the evolution of the Ohio River Valley drainage before and after the Pleistocene ice ages. Prior to the advance of glacial ice, the Ohio River was but a small tributary to the Mississippi River. Drainage of the Appalachian area was further north. Upon advance of thick glacial ice during the Pleistocene, the northern drainage was dammed and water was forced to carve the Ohio River Valley. This in turn caused major downcutting of the Green River, a tributary to the Ohio. Many smaller tributaries became disappearing rivers, diverting underground because they were unable to keep pace with downcutting. Different levels of cave excavation and development correspond to the drainage, downcutting, depositional, and ice age history of the entire region. These connections are complex and not yet well understood.

The cave's stable environment (even temperature and humidity) supports a vast biodiversity of microbiological, invertebrate, and vertebrate species. Many of these have evolved special features as a result of adapting to life in the caves.

The park contains some lacustrine features including upland swamps (containing acidic bog deposits). Upland wetland habitats are often associated with perched local aquifers atop the impure Haney Limestone, and the sandstone rich Big Clifty Formation. These perennial wetland areas are scarce in the karst landscape and provide vital surface water to plants and animals in the area. Acidic fern bogs are associated with local karst formation. Other lacustrine features include sinkhole ponds. These features are typically ephemeral. After a period of precipitation, water is present, but subsequently drains, fills, or dries up during a dry period. Within the cave, local slurry flows may reflect sudden draining of a sinkhole pond or collapse (at Labyrinth).

Recommendations

(1) Perform comprehensive park-wide fault mapping on the land surface, within sinkholes, and in caves.
(2) Identify long-term geologic information needs.

(3) Investigate possibility of integrating the NPS-GRE Geodatabase with the cave/karst Geodatabase being developed by Aaron Addison.
(4) Inventory, map, and describe the more than 300 small caves within park boundaries. Obtain baseline biological, geological, hydrological, and hazard information for each in order to set up routine monitoring.
(5) Perform mapping of Quaternary floodplain and river terrace deposits. The KGS is currently mapping Quaternary geology in the western Kentucky – Ohio River area.
(6) Research fluvial geomorphology in cave streams as well as the Green River. Perhaps a cooperative effort with the park would facilitate similar mapping at Mammoth Cave.
(7) Continue to inventory paleontological resources within the cave and extend inventory to the surface at the park. Excavations, if deemed appropriate by expert consultation, and inventories should include dating and identifying all fossil remains (distinguishing between extinct vs. extirpated species as well as the number of individuals for comparison with current population lists and ranges), collecting pollen and C14 samples from each natural level. Exercise care in collecting any charcoal deposits. Store and catalogue samples into park collections.
(8) Perform more dye trace tests and groundwater flow mapping especially in the Cub Run area and other regions north of the park boundary, but part of the biosphere.
(9) Research the fire history of the region.
(10) Identify correlations between biology and geology such as the presence of sandstone controlling the distribution of chestnuts, or the chinkapin oak's (*Quercus muehlenbergii*) preference for limestone soils.
(11) Develop a karst sensitivity and vulnerability map.
(12) Study the relationships between geology and water quality. Monitor springs for pH, aluminum, mercury and attempt to determine nature of mobilization, transportation, and aerial distribution from nearby coal powerplants.
(13) Perform research regarding the natural fluctuations in relative humidity and temperature, and wind speed and direction in various sections of the cave system.
(14) Perform inventories to establish baseline conditions for future monitoring of the health of the cavern watershed, flow regimes, and water chemistry.
(15) Continue to research speleogenesis, paleoclimatology, and cave sediments for interpretation and management purposes.
(16) Perform a faunal study of the cave's biota including microbiological, invertebrates, and vertebrate species focusing on the number and identification of obligate and facultative cave species as well as accidental and species that use the cave only in the dark and twilight areas.
(17) Cooperate with local universities to perform microbiological testing, visual surveys, live trappings, and limited pitfall trapping of cave species.
(18) Perform archaeological testing focusing on the entrances and in the twilight zone areas as well as the dark zones of the cave. Conduct oral histories to document the more recent use of the caves prior to park establishment. This study is time sensitive as historical figures are aging. Historic photographs (personal and commercial) and written accounts should also be collected.
(19) Work to refine the speleogenesis model employed at the park.
(20) Perform a mineralogical inventory of the caves, focusing on pre-cave mineralogy.
(21) Use oxygen isotope tests to gain information on the types of overlying vegetation at the park through time to understand more of the area's paleoclimate. Relate isotope information back to hydrologic system at the park.

(22) Work to refine the karst and hydrologic systems at Mammoth Cave using tracers, and isotope studies to delineate aquifers and flow systems including recharge dynamics in the cave network.
(23) Perform studies to determine how release of impoundment of the Green River at lock and dam #6 would affect cave hydrology.
(24) Study the effects of pumping on the hydrologic system at the park.
(25) Perform a comprehensive biological inventory to establish baseline conditions for future monitoring. Focus on ecosystem level and interrelationships between biological resources and geology-hydrology of the cave and karst system. Use results to create an ecological risk assessment and working ecosystem model.
(26) Install aenomometers at all 29 cave entrances to map airflow in the cave system.
(27) Map dust dispersion in the cave system and relate to trails and airflow.
(28) Study the response of the cave microclimate to heating associated with lighting (and heating) of the cave.
(29) Use cave spatial information and digital geologic map to predict locations of new caves based on known relationships (i.e. small caves along certain geologic contacts, etc).
(30) Continue cave mapping along survey lines for incorporation into a GIS environment.
(31) Acquire geologic maps of areas beneath reservoirs.

Action Items

(1) GRE report writer will obtain detailed stratigraphic information of Mississippian age, cave supporting units from Art Palmer (?).
(2) GRE will produce digital geologic map for the site (see above geologic mapping section).
(3) Park may be interested in the KGS land use planning maps derived by the KGS. These maps are derivative products that reclassify geology into a basic lithologic map that is produced for non-geoscientists/layperson. Map illuminates how rocks area related to basic land uses for a specific county; map can encompass issues for park management as well as park visitors. Matt Crawford is an available contact for this information. Contact Bob Higgins (NPS-GRD) if interested.
(4) GRE report writer will find publications based on research by Joe Ray (KY Division of Water) on the geomorphological features, surficial mapping, and the development of Kentucky's karst landscape. Ray also produced general topographic maps of river channels and paleoriver channels and terraces that should be accessed for the final GRE report.
(5) GRE report writer will obtain paper regarding the ecology of lock and dam 6 (provided on CD by Rick Toomey)
(6) GRE team will examine oil and gas layers kept by the KGS (Oil and Gas of Beaverdam 30x60 Quadrangle, KY) and attempt to obtain oil and gas information for the area.
(7) GRE report writer will ask Rick Olson about other habitat/geology connections for the map unit properties table.
(8) GRE mapping team will explore possibility of linking digital geologic map with Aaron Addison's cave geodatabase

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Table 2. Scoping Meeting Participants

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